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# Facilitation and practice in verb acquisition*

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ABSTRACT

This paper presents a model of syntax acquisition, whose main points are as follows: Syntax is acquired in an item-based manner; early learning facilitates subsequent learning – as evidenced by the accelerating rate of new verbs entering a given structure; and mastery of syntactic knowledge is typically achieved through practice – as evidenced by intensive use and common word order errors – and this slows down learning during the early stages of acquiring a structure.

The facilitation and practice hypotheses were tested on naturalistic production samples of six Hebrew-acquiring children ranging from ages 1;1 to 2;7 (average ages 1;6 to 2;4 months). Results show that most structures did in fact accelerate; the notion of 'practice' is supported by the inverse correlation found between number of verbs and number of errors in the earliest productions in a given structure; and the absence of acceleration in a minority of the structures is due to the fact that they involve relatively less practice.

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## INTRODUCTION

This paper presents a syntax acquisition model, which focuses on the syntax of clauses constructed around verbs, and posits that syntactic development entails facilitation from verb to verb. This leads to acquisition of new structures which is slow at first but which accelerates as learning proceeds. I suggest that the slow start is actually a practice period, during which the child may show a relatively strong propensity for making word order errors. Syntactic knowledge at this early stage is posited to be item-based, and need not involve the acquisition or use of abstract concepts. The main claims of the model are tested on data from the naturalistic production corpora of six children acquiring Hebrew as their first language. This work is an extension of Ninio's model (1999*a*, *b*, 2005).

Most of the early theories of syntactic acquisition conceptualize children's syntactic knowledge as relating to large abstract categories. These theories assume that the linguistic units to which syntactic rules apply are more abstract than those which actually participate in the final utterance; i.e. they are not mere words. This is true of theories which posit a grammatical or structural criterion for inclusion in a category (e.g. Braine's 1963 pivot grammar), of nativist approaches (e.g. Pinker, 1984; Valian, 1991), and of early semanticist approaches, which suggest a semantic criterion for inclusion under each relation (e.g. Brown, 1973; Braine, 1976; Schlesinger, 1995).

At the other extreme are theories which claim that children's syntactic knowledge, up to a very late stage, is verb-specific (or item-specific), and that no knowledge is transferred from one verb to another or from one pattern to another. These include the theories of Tomasello, Lieven and Pine and their associates (e.g. Tomasello, 1992; Lieven, Pine & Baldwin, 1997). The present model is very close in spirit to those of Tomasello and his colleagues and Pine and Lieven and their colleagues, although I do not believe that syntactic development proceeds in a 'verb-island' fashion (to use Tomasello's term), whereby early knowledge about one verb has no effect on the acquisition of subsequent knowledge about other verbs (but see Uziel-Karl (2001) for an application of the verb-island approach to the acquisition of Hebrew).

My point of departure is Ninio's model of syntactic development. Ninio (1999*a*, *b*, 2005) suggests that the first verbs learned in VO (verb + object) and in SVO (subject + verb + object) structures serve as 'pathbreaking verbs', paving the way for new verbs to be learned in those structures: the more verbs a child acquires in a given structure, the easier it becomes for that child to learn new verbs in that same structure. Ninio also claims that the earliest verbs acquired in a structure tend to be generic, 'expressing the relevant combinatorial property [of verbs of their valency structure] in a relatively pure fashion'. The model I am proposing seeks to complement

Ninio's model and elaborate on it, by proposing that the first stage in the acquisition of a structure is a stage of practice and trial and error; by elaborating on the mechanism responsible for the transfer of knowledge from early verbs to later ones; and by showing that the same kind of learning occurs in all structures, not only in VO and SVO. One aspect in which my work differs from Ninio's is that I look at the development of structures, whereas Ninio follows the development of grammatical relations. This primarily affects the way data is analysed.

The next section, which outlines the model, describes the proposed learning process in more detail, merging Ninio's ideas (e.g. 1999*a*, *b*, 2005) with mine to present a coherent story.

The structure of this paper is as follows: the first section outlines the model and the next section operationalizes it. Then there is a brief detour to describe some relevant properties of modern Hebrew. This is followed by the methods, results and conclusions sections.

## THEORETICAL OUTLINE OF THE MODEL

The concept of STRUCTURE occupies a focal position in this paper, and it is therefore important to clarify the sense in which it used. In what follows, each structure is taken to constitute a unique combination of one or more argument types with a verb, such that SVO (subject+verb+object), VO (verb+object), and SV (subject+verb) are three different structures.

It has been found that the first verbs learned in each structure tend to be generic, relative to the group of verbs sharing their argument structure (see Ninio (1999*a*, *b*) for SVO, VO and intransitives in combinations in Hebrew and English; Vihman (1999) for a bilingual Estonian-English child's intransitives, VO and SVO; Keren-Portnoy (2002) for a great majority of the structures of Hebrew. However, see Campbell & Tomasello (2001) on ditransitives). Generic verbs have very general semantics, which constitute a virtual schema of the semantics of verbs of their valency. As such, they may be thought of as prototypes of their category, having primarily characteristics that are common to many other items in the category, and few, if any, distinguishing specific characteristics, thus being the 'average' or typical item in the category. This makes them easy to learn as first verbs (see Mervis & Pani, 1980), and also makes them excellent models for analogy to other verbs of the same valency: the prototype is the item most similar to the largest number of other items in its category (Mervis & Pani, 1980; Hahn & Chater, 1998). Therefore, the prototype is a very useful first item to learn. When a new item is encountered, and a search for similar items in storage is launched, the prototype is the item which is most likely to surface as the nearest and most similar item, and the one which will enable analogy to take place most efficiently (for a more thorough discussion of the genericness of the first verbs in each structure, see Ninio (1999*a*, *b*), and Keren-Portnoy (2002)).

What kind of information is stored about each newly acquired verb in a given structure, and how is it stored? This knowledge may be stored in the form of exemplar utterances, or as schemas, either of which apply specifically to a given verb. It is suggested that the knowledge relevant to each verb is stored as such for that verb's representation in memory, not as generalized knowledge concerning abstract categories like VERB or ACTION or TRANSITIVE CONSTRUCTION. As regards the verbs, then, knowledge is stored for each one individually. However, as regards the verb's arguments, the stored information may be very specific or very general: it may apply to specific words or to more abstract concepts. Consider, for example, the verb 'to eat': after having produced the utterance 'eat it', children may store this specific utterance with the verb's representation, or they may store a schema of the form 'for "eat" one must put "it" after "eat"'. Alternatively, they may store a much more general schema concerning that specific verb's possible arguments: 'for "eat" one must put the "thing eaten" after "eat"'. To repeat, it is posited that under all these alternatives, any stored knowledge refers to one specific verb. It need entail no abstraction concerning that verb, although it may contain abstractions concerning the arguments of the verb, and these may evolve over time. This is in accordance with the claims about the asymmetry in acquisition between verbs and nouns, which maintain that children develop an abstract noun category early but develop an abstract verb category only at a much later age (Ninio, 1988; Tomasello, 2000).

The first verb acquired in a structure can already facilitate the acquisition of those to follow. It is suggested that facilitation proceeds by analogy on the basis of similarity in semantics and in valency. For example, if a child wants to construct an utterance which includes 'drink' with 'what is drunk', she can base that utterance on the model of 'eat', for which she has already stored information concerning the construction of utterances containing 'eat' and 'what is eaten'. The child must take into consideration both semantics and argument structure, as in some cases semantic similarity is not accompanied by similarity in valency. Nevertheless, argument structure can by and large be inferred from semantics (Levin, 1993). It must be stressed that in this model analogies enable the transfer of past solutions from a previously used verb to new verbs. Analogies need not involve abstractions, nor do they necessarily lead to abstractions. Such similarity-based reasoning – the term is taken from Hahn & Chater, 1998 – has been described in the literature on categorization and on reasoning through analogies (Medin & Schaffer, 1978; Gick & Holyoak, 1983): knowledge about the usage of a new item does not necessitate retrieval of the concept or category that the item belongs to. Knowledge can be gained through the retrieval of the most similar previous item in storage and the use of the new item in a manner similar to that in which the previous item has been used. In this aspect the model proposed here differs from other models of syntactic development, where analogies serve as a mechanism which leads to abstractions: e.g. Tomasello (2000).

The clearest evidence for facilitation occurring between different verbs is the decreasing time lag between the acquisition of consecutive verbs, as demonstrated by children's productions (Ninio, 1999*a*, 2005). Acceleration in the rate of new verbs joining the structure demonstrates that learning to use new verbs in a given structure becomes gradually easier as the number of verbs already learned in that structure grows. This phenomenon demonstrates dependence among the different verbs learned in a structure. A verb cannot constitute an insulated 'island of knowledge' if its ease of acquisition is dependent on the history of previously learned verbs. It follows that the acquisition of new verbs in a structure is based on and facilitated by previously acquired verbs. Ninio (1999*a*, 2005) has already found this pattern of facilitation in about 20 corpora in Hebrew and one in English, for utterances of the form VO and SVO. Vihman (1999) reports a similar pattern, in the corpus of an English-Estonian bilingual child, for combinations with intransitive verbs in Estonian and English and for utterances of the form VO in Estonian. Kiekhoefer (2001) reports similar results for the ditransitive construction in the corpora of two children, one acquiring German and the other English. Abbot-Smith & Behrens (in press) found such patterns for several constructions ('*ist*' + NP', '*ist* + adjective', '*hat* + participle', '*wird* + passive', '*wird* + adjective') in the corpus of a German-acquiring child. Elbers (2000), looking at a somewhat different syntactic phenomenon, also found that early learning facilitates and accelerates later learning in verbs. Analysing the corpus of one child (T, described in Tomasello, 1992), she followed the occurrence of IT-REDUNDANCY in the corpus, i.e. cases where the object of the verb is expressed with both the pronoun 'it' and another object term, such as *find it-bird*. She found 'a gradual rather than a sudden disappearance of it-redundancies … [which] suggests that analysis of post-verbal *it* took place verb-by-verb'. However, she found that the age at the first occurrence of a given verb with 'it' correlates strongly with the time interval until the last occurrence of it-redundancy for that verb. She concludes that there is an effect of earlier analysis on later analysis, such that the later item profits from the analysis of the earlier item, and therefore its analysis will take somewhat less time. Finally, she concludes that 'there seems to be a gradual 'acceleration' of the process of item-by-item analysis itself'.

The learning of a new structure starts out slowly and accelerates gradually. But what is it that goes on during that first period of learning, when learning is slow, and the time lag between the acquisition of any two consecutive verbs is relatively long? Why the slow beginning? What stops a child who has already successfully used one verb in a structure from going right ahead to use additional verbs in that structure? What keeps rapid learning from taking off right from the start? Conversely, if some structures are found where an accelerating pattern is not seen, can this be explained as an absence of the factors which cause the delays found in most structures?

The literature on exemplar learning and analogies stresses the fact that with only a single item as a model, analogizing and categorizing are more difficult than when several items have previously been acquired (Gick & Holyoak, 1983). The explanations given are that a larger number of items learned helps to calibrate the weights of different characteristics of these items, a process which is necessary for effective comparisons, analogies or categorizations. Calibration may be thought of as finding out which characteristics of the learned item are important for the task at hand and for analogizing from a given item to others. Returning to the topic of syntax acquisition, learning by analogy should be difficult as long as there is only a single verb serving as a model in a given structure, and it should become progressively easier as additional verbs are learned in that structure. This is not to say that any generalization is taking place. Learning continues to be tied to specific verbs, but the transfer of knowledge from one verb to another gets progressively easier.

It is postulated that the process leading to calibration in syntax learning takes the form of practice. Children practice the use of new verbs by using them over and over again, trying out solutions, at times making errors, then trying again. In this process of repeated trial and occasional error, the child learns the significance of word order: that a verb has at least two sides to it, so that a decision has to be made – which word belongs on which side of the verb. At first the decision may be made erratically and unintentionally, but since speech is sequential, a decision must be made each and every time that two or more words are uttered in combination. Gradually, the child must learn to differentiate between the two possible slots on either side of the verb, and to understand that different arguments are placed in different slots (Veneziano, 1992). Practice must lead, therefore, to the realization that the number of arguments a verb has, and their different relations to the verb, are important characteristics of that verb. These characteristics must be taken into account when constructing utterances with any given verb and when analogizing from it to other verbs. In a very similar spirit, Elbers & Wijnen (1992) and Elbers (2000) propose a model of language acquisition where development is brought about through practice and through children's analysis of their own past productions.

The first and most straightforward condition needed to establish a claim of practice is intensive usage, and there is some evidence in the literature of early items being frequent in children's speech (Forner, 1979), and of a tendency to 'play' with newly acquired combinations (Bar–Adon, 1968), and to 'try them out' (Elbers & Wijnen, 1992), as in crib-speech or in communicatively superfluous self-repetitions. Somewhat indirect evidence for early verbs being frequent in children's combinatorial speech may be inferred from studies showing a relationship between frequency in parental input and order of acquisition of a verb in a given structure (Theakston, Lieven, Pine & Rowland, 2001), taken together with studies showing a relationship between parental frequency and child frequency of verb use within a given structure (Campbell & Tomasello, 2001; Theakston, Lieven, Pine & Rowland, 2001). These two lines of research taken together imply that the early verbs used by children in a given structure are frequent in children's speech, not only in parental speech. In other words, verbs which are learned early in a given structure seem to be used intensively in that structure, as the practice hypothesis suggests. Indeed, evidence from the six Hebrew-acquiring children whose corpora form the empirical data of this paper shows that early verbs in each structure tend to be more frequently used in that structure than later-learned verbs, more so than can be explained by the mere fact that they have been in use longer than later verbs (Keren-Portnoy, 2002).

I have suggested above that children use the early phase of acquisition of any new structure for working out and thinking through the problems of how to combine a verb with its arguments. Word order errors made during that early period can be taken as evidence for such problem solving processes. They demonstrate that this is a period of trial and error. And indeed, previous work on syntax acquisition mentions the occurrence of errors (e.g. Brown, 1973; Elbers, 2000) or groping for the correct word order (e.g. Braine's groping patterns (1976)) in the early stages of acquisition of structures (see also Uziel-Karl (2001), for examples of groping patterns in the productions of Hebrew-acquiring children). In addition to errors being evidence of practice, they also act as obstacles to successful analogy. Early word order errors or cases of groping for word order (which will henceforth be treated as errors) are evidence that incomplete, unclear, or even erroneous or conflicting schemas have been formulated for the verb in question. Such defective schemas may cause use of the verb to be problematic, perhaps not automatic, often accompanied by hesitation. Such a verb may therefore be difficult to use as a model for other verbs.

Although there is ample evidence in the literature that syntactic development involves acceleration, cases have been reported of learning which progressed at a constant rate from the start. Vihman (1999) followed the syntactic development of her bilingual Estonian-English learning child. She reports that learning seems to proceed at a constant rate for word combinations involving non-verb predicates in both languages, and for SVO structure in Estonian and VO and SVO structures in English. Abbot-Smith & Behrens (in press) who studied a dense corpus of a German learning child, find that later-acquired constructions, whose learning is supported by earlier-acquired constructions, are mastered all at once, and do not show a pattern of acceleration. A similar phenomenon has also been reported in a different area of language development: lexical acquisition. Goldfield & Reznick (1990) describe a minority of learners who fail to exhibit the expected pattern of acceleration in the rate of acquisition of new words, the so called VOCABULARY SPURT.

In syntactic acquisition such non-accelerating structures need not be interpreted as signifying that no facilitation is operating between early and late verbs, but they certainly do not give any evidence of its occurrence. It is possible that there is a minority of cases where learning does occur without any facilitation, and each verb is indeed an 'island of knowledge'. However, there is also another possibility, namely, that facilitation does play a role in the non-accelerating structures as well, but that the rate of learning is rapid from the very start. These may be instances where learning is effective and calibration successful right from the start, so that no practice period is necessary and the immediate acquisition of additional verbs is possible. This may be the result of a lucky guess, stumbling by chance upon the correct solution.

Conversely, this phenomenon may be a sign of a cautious beginning (or maybe a cautious beginner) – where problems are thought out and solved before production kicks in, and therefore no evidence of trial and error is found. This may characterize the learning style of some children, but not of others.

What are the implications of the proposed learning model to the end-state, adult grammar? The categories which result from similarity matching exhibit characteristics such as graded membership, better performance on prototypes, etc. (Medin & Schaffer, 1978). Although these very characteristics are often taken as evidence of a category's being constructed around a computed, abstract prototype, it is not necessary to assume such abstraction: exemplar learning, which does not involve abstraction of prototypes, leads to categories which are very similar in structure to those allegedly constructed around prototypes. Therefore, descriptions of adult linguistic categories as prototype-based are quite compatible with the possible end-state of the learning process suggested here and indeed, many researchers describe adults' linguistic categories as prototype-based (e.g. Schlesinger, 1995; Taylor, 1998; Goldberg, 1999), while some describe linguistic knowledge (but mostly phonology and morphology) as exemplar based (e.g. Bybee, 2001).

## OPERATIONALIZATION OF THE RESEARCH QUESTIONS

The evidence for facilitation and practice is based on naturalistic production data from six Hebrew-acquiring children. The data-points are the individual structures found in all these corpora taken together: each structure in a given corpus is a data point. Fifteen different structures were investigated. Had they all been represented in each of the six corpora, there would have been $15 * 6$ or 90 structures altogether, each of which would have served as a single data point. Thus the SV structure found in the corpus of Naomi is one data point, the VO structure found in the same corpus is another, and the SV and VO structures found in the corpus of Shuli are two additional data points.

Hypothesis 1 (below) tests the claim of facilitation. As mentioned above, facilitation can be established by observing the change in the rate of learning new verbs in any given structure. Acceleration in the rate of new verbs joining the structure, i.e. an increase in the number of new verbs learned in a structure in a given period of time as learning progresses, can be taken as a sign of facilitation from earlier-learned verbs to later-learned ones.

All the structures in the data-base were inspected for evidence of facilitation in the form of an accelerating learning pattern. The date on which a particular verb is considered to have joined a structure, or when it has begun to be learned in that structure, is the date on which it was first used in that structure in a clause with canonical word order (for a detailed definition of CANONICAL ORDER, see the 'method' section). Note that I am looking for the earliest stages of learning to use a verb correctly in a new structure, and therefore take the first correct use as the starting point (however, when looking for evidence of practice, the very earliest clauses are examined, regardless of their canonicity). Acceleration in the rate of learning is operationalized as an increase in the number of verbs joining the structure in any given time period as time progresses. The cumulative frequency of new verbs joining the structure at any given date is plotted, and the shape of the resulting curve is checked. If the time lag between every two consecutive verbs learned in the structure becomes progressively shorter, then the graph will be an accelerating one, i.e. a convex curve. The first hypothesis to be tested is therefore:

*Hypothesis 1, facilitation*: the majority of the structures in the corpora will exhibit an accelerating pattern of development.

Hypothesis 2 (below) tests the claim of practice. The relative number of errors and the relative number of verbs used in the first stages of learning a structure are used to operationalize practice. If a structure undergoes intensive practice, each of the first few verbs learned in that structure is expected to generate a relatively large number of clauses, because each such verb is used relatively many times when it is practiced. Therefore, the first clauses formed in a particular structure would be expected to involve a smaller number of different verbs if that structure is undergoing intensive practice. In addition, structures which undergo intensive practice would be expected to generate a relatively large number of erroneous, non-canonical clauses because, as claimed above, practice often involves error-making as part of the, possibly unconscious, search for the 'correct' solution. Although practice need not NECESSARILY involve errors, once usage is mastered, errors should certainly become rare. Errors can thus help to differentiate between structures that are in the process of being learned and structures which have already been mastered. It is therefore expected that an inverse relationship would be found between the number of verbs which generate the first clauses produced in each structure and the number of errors made in these first clauses. The second hypothesis is:

*Hypothesis 2, practice*: a negative correlation will be found between the rate of errors in the early stage of acquisition of a structure and the rate of new verbs entering into this structure in that early stage.

Two further hypotheses were tested, intended to demonstrate that non-accelerating structures undergo less practice than accelerating structures. First, I checked whether early verbs in these structures are used less intensively, i.e. whether each verb generates fewer clauses, so that more different verbs will have generated the earliest clauses in each structure. Secondly, I checked whether the non-accelerating structures include fewer clauses with non-canonical word order. If both these predictions are borne out, it will be concluded that the non-accelerating structures are cases where learning could proceed smoothly from the start. Therefore such non-accelerating structures need not be taken as evidence for lack of facilitation of later by earlier learning.

The third and fourth hypotheses are therefore:

*Hypothesis 3, number of verbs and acceleration*: structures with a non-accelerating learning curve will be characterized by a higher rate of different verbs within the first 20 clauses than structures with an accelerating learning curve.

*Hypothesis 4, errors and acceleration*: structures with a non-accelerating learning curve will be characterized by lower rates of errors within the first 20 clauses than structures with an accelerating learning curve.

### *A short description of Israeli Hebrew*

A concise description of some aspects of Israeli Hebrew (IH) which are relevant to the current study is in order. WORD ORDER IN THE SIMPLE CLAUSE: IH is a nominative/accusative language with a basic SVO word order (e.g. Glinert, 1989; Berman, 1990, 1994), which is much less rigid than that of English. SV(O) order is used in the majority of parental utterances addressed to children (Buium, 1974; Berman, 1994). However, clauses in IH may be constructed with a non-canonical word order as a result of three pragmatic functions: focalization, topicalization, and presentation (Givón, 1976; Glinert, 1989), and children are exposed to these VS constructions (Yael Ziv, personal communication). Unlike other pragmatic functions which affect word order, the presentational function tends to be carried by a

TABLE 1. *The corpora*

| Child's name | Age at first recording | Age at last recording | Number of recordings |
|---|---|---|---|
| Bareket | 1;1.8 | 1;10.20 | 34 |
| Lior | 1;7.16 | 2;3.5 | 25 |
| Naomi | 1;6.25 | 2;7.22 | 51 |
| Ofer | 1;6.14 | 2;6.16 | 45 |
| Shuli | 1;5.25 | 2;4.8 | 125* |
| Tal | 1;7.22 | 2;3.27 | 28 |

* Twice a week.

particular set of verbs (Givón, 1976; Berman, 1982, 1994). A subset of such verbs, which are often modeled in the input in VS word order, are also often produced in utterances with this word order by the children, as evidenced by the data in the current study (and as claimed by Berman, 1982, 1994). This subset includes such verbs as *nigmar* 'to finish (intr.)', *nishbar* 'to break (intr.)', *kaav* 'to hurt (intr.)'. These are often accompanied by the possessive dative and often tend to have non-human, non-agentive subjects. (Here and elsewhere Hebrew verbs are cited in the past tense 3rd person masculine singular.) VERB INFLECTION: Verbs are inflected for tense, gender, number and person. In the present tense verbs are inflected for gender and number only. Present tense forms may often serve also as adjectives or nouns (Rosén, 1962, pp. 199, 211, refers to such forms as the 'aorist tense'). SIGNALLING GRAMMATICAL RELATIONS: Grammatical relations between a verb and its arguments can be indicated by word order, case (subject and indefinite direct objects are unmarked, and other cases are marked by prepositions), and agreement of the verb with the subject (Berman, 1994).

## METHOD

### *Participants and corpora*

The dataset consists of the production corpora of six children acquiring Hebrew as their first language. One child received some input in English, but he himself spoke only Hebrew. Data collection began before the children produced any word combinations and continued for 8 to 13 months. Five of the children were audio-recorded weekly for about half an hour. One girl was recorded twice weekly, for 20 minutes a session. All the children were recorded while engaging in naturalistic interaction with a parent. The average age at the first recording session was 1;5.29 and at the last session 2;4.1 (see Table 1). Two of these corpora were collected by me as part of my PhD research. Three others were collected by students who participated in a research seminar given by Professor Anat Ninio. One was recorded by her father. The recordings were later transcribed by the observers in Hebrew, using standard orthography, without trying to portray the children's precise pronunciation, as neither phonetics/phonology, nor morphology were at the focus of the research. In many cases, however, the transcribers did note (in broad phonetic transcription) the phonetic realization of the verbs. The recordings were supplemented by parents' written reports of utterances heard in between recordings; these reports were excluded for one child because they differed to a great extent from the data collected by the researcher, in terms of the verbs documented as being produced in combinations by that child. In addition, some of the observers documented additional utterances which they had heard outside of the weekly half hour.

### *The productions analysed*

All clauses which consist of a verbal predicate with all or some of its arguments were analysed. Utterances with hesitation or pauses are treated as unitary utterances, but not so vertical constructions, where the words belong to different turns in the conversation, with another speaker's turn intervening. In many cases, each utterance contained only one clause. When an utterance contained more than one clause, it was divided up, such that each clause was analysed separately, whether it contained a finite or a non-finite verb. However, if one clause served as an argument of another, only the main clause was analysed. Therefore, all the following were analysed separately: coordinated clauses, relative clauses, adverbial clauses (the latter only when not serving as obligatory adverbial arguments). Cases of ellipsis are not dealt with as a special phenomenon, because clauses were assigned to structures according to the arguments which are actually expressed in them, not according to the verb's possible or full argument structure. Only utterances which were complete (uninterrupted), intelligible, comprehensible and spontaneous were analysed. Clauses which were constructed around non-verbal predicates such as the forms *yesh* and *eyn* (which signify existence and possession or lack thereof) were not analysed, and likewise clauses constructed around the aorist forms, which were analysed if the aorist served as a verb in the present tense but not when it served as an adjective or noun. Nor were clauses constructed around the verbs *haya* 'to be' and *nihya* 'to become' analysed, because they participate in possessive clauses and in copular clauses which are different from the rest of the clauses followed here, and do not contain a verbal predicate in the present tense in Hebrew. Wh-questions, in which argument location is determined by the question form and not by the verb (Glinert, 1989), were not analysed. In contrast, Yes/No questions, which are differentiated from declaratives only by rising intonation, were analysed.

Vocatives were not treated as subjects of the verb.[1]

Sentential complements, whether constructed as subordinate clauses with a subordinator or as infinitival clauses, were treated as objects of the verb, and modals with an infinitival predicate were also analysed in this way. This is in accordance with traditional grammarians' view of Hebrew (see, for instance, Rosén, 1962, p. 67).[2] All the different forms of a verb are categorized as the same verb, irrespective of their inflections for gender, person, tense, and number, including infinitives.

### *The structures under study*

The arguments looked at were:

(1) Subject (S)
(2) Direct object (O) (including sentential complements)
(3) Indirect object (I) (including all datives and obliques)
(4) Obligatory adjuncts (A). This category included mostly adjuncts indicating goal, source, location, and in rare cases, time or manner.[3]

Fifteen structures were investigated. These are listed in Table 2. For each structure, the first clause to be constructed in that structure in one of the corpora is listed. (The transcriptions follow adult pronunciation, and do not attempt to approximate the children's actual form of production in terms of phonetics or morphology. The glosses also describe the hypothesized adult 'target' forms.)

### *Coding: definitions, problems, decisions*

Each clause was coded as having one structure only. That is, clauses of the form SVO were not coded as instances of SV or VO as well. In this sense the classification scheme is exclusive, in that there is no overlap between

[1] There were cases where it was unclear whether the structure was a vocative with verb, or a subject with verb. This is due in part to the fact that children often omit the inflectional marking of tense, person and number, which makes it impossible to definitively identify the target form of the verb, if such a 'target form' does exist. In cases of uncertainty the default decision was to consider these utterances as cases of vocative with verb, and not subject with verb.

[2] Rosén discusses cases in which the object of a verb is a sentence or an infinitive. Among his examples of verbs which take infinitival objects are some modal verbs: *hiskim* 'to agree', *hitsliax* 'to succeed', *hifsik* 'to stop'.

[3] Obligatory adjuncts were considered arguments. Some (though not all) scholars of Hebrew see the adverbial complements of 'motion verbs' as obligatory (e.g. Stern, 1994). Goldberg, Casenhiser & Sethuraman (2004) also treat adjuncts as no different from arguments (they refer to locative phrases), but they justify this decision by saying that they do not assume that 28-month-olds have already mastered the argument – adjunct distinction.

TABLE 2. *The 15 potential structures*

| | | |
|---|---|---|
| 1 | subject + verb Bareket, age 1;4.9: *Aba halax*, Daddy go-3SG-MS-PT 'Daddy went' | SV |
| 2 | verb + direct object Lior, age 1;11.1: *rotse et ze*, want-SG-MS-PR ACC this '[I] want this' | VO |
| 3 | verb + indirect object Tal, age 1;10.28: *ten le-maya*, give-2SG-MS-IMP to-maya 'Give Maya' | VI |
| 4 | verb + obligatory adjunct Tal, age 1;9.10: *lexi mi-po*, go-2SG-FM-IMP from-here 'Go away' | VA |
| 5 | subject + verb + direct object Ofer, age 2;1.2 *Ofer yekabel melon?*, Ofer get-3SG-MS-FUT melon? 'Will I get some melon?' | SVO |
| 6 | subject + verb + indirect object Naomi, age 2;0.24: *Ima taazor lax!*, Mommy help-3SG-FM-FUT to-you 'Mommy will help you!' (a request for help from Mommy) | SVI |
| 7 | subject + verb + obligatory adjunct Ofer, age 2;1.2: *Aba axshav yavo Ofer?*, Daddy now come-3SG-MS-FUT Ofer? 'Daddy will come to me now?' | SVA |
| 8 | verb + direct object + indirect object Bareket, age 1;9.28: *tni li lehikanes*, let-2SG-FM-IMP to-me enter-INF 'Let me enter' | VOI |
| 9 | verb + direct object + obligatory adjunct Shuli, age 2;0.4: *lasim et ze kan*, put-INF ACC this here 'Put this here' | VOA |
| 10 | verb + indirect object + obligatory adjunct Shuli, age 2;1.14: *koev li kan ba-yadayim*, hurt-SG-MS-PR to-me here in-the-hands 'Hurts to me in here in the hands' (My hands hurt here) | VIA |
| 11 | subject + verb + direct object + indirect object Ofer, age 2;1.18: *Ruth kanta Ofer riba?*, Ruth buy-3SG-FM-PT Ofer jam? 'Did Ruth buy me jam?' | SVOI |
| 12 | subject + verb + indirect object + obligatory adjunct Naomi, age 2;3.12: *ze koev li po*, this hurt-SG-MS-PR to-me here 'This hurts to me here' (It hurts here) | SVIA |
| 13 | subject + verb + direct object + obligatory adjunct Ofer, age 2;3.25: *ha-ish hixnis yad letox ha-helikopter bifnim*, the-man put-in-3SG-MS-PT hand into the-helicopter inside 'The man put a hand inside into the helicopter' | SVOA |
| 14 | verb + direct object + indirect object + obligatory adjunct Naomi, age 2;4.10: *nasim lo trufa ba-rosh*, put-1PL-FUT to-him medicine in-the-head 'We'll put medicine on his head' | VOIA |
| 15 | subject + verb + direct object + indirect object + obligatory adjunct Naomi, age 2;4.10: *Ima yavi li oto, et haxalav, hena*, Mommy bring-3SG-MS-FUT to-me ACC-3SG-MS, ACC the-milk, to-here 'Mommy will bring it to me here, the milk' | SVOIA |

clauses belonging to two different structures. This contrasts with the method followed by Ninio (1999*a*, *b*, 2005), as her classification scheme is inclusive, so that all utterances of the form SVO are also seen as instances of SV and VO.

Each clause was coded as having a canonical or a non-canonical word order. The word order of a clause was considered canonical if the subject preceded the verb and all the other arguments followed the verb, with the internal order among the other arguments irrelevant to the issue of canonical order. An example of a NON-CANONICAL clause, due to the verb preceding the subject, can be found in Shuli's corpus at 1;7.2: *afa ze*, fly-SG-FEM-PR this 'this is flying'. Immediate repetition of a single word within a clause was not seen as an error in word order. An example for such a case from Shuli's corpus at 1;7.2 is: *ze ze ze af*, this this this fly-SG-MS-PR 'this is flying'. This was seen as a canonical clause. However, if an argument (or the verb) was repeated in a clause in more than one location, that clause was considered non-canonical. An example of such a case from Naomi's corpus at 1;11.1 is: *rotsa Naomi rotsa ken*, want-SG-FM-PR Naomi want-SG-FM-PR yes 'Indeed I want [cookies]'. This was coded as a non-canonical clause.

It is of course not always clear how a sequence of words produced by a very inexperienced speaker should to be divided into utterances. Often, when there are long pauses between the words, prosody cannot aid in the decision. Thus a sequence like the following one from Naomi at 2;3.2: *ananim. rotsa ananim*, clouds want-SG-FM-PR clouds 'Clouds. [I] want clouds.' could also be cut up as *ananim rotsa. ananim* 'Clouds want. Clouds.', or even as three one-word utterances. In deciding how to cut up such sequences into utterances the punctuation marks of the transcriber were respected, all the while bearing in mind the fact that transcribers tend to be motivated by the principle of charity, and to punctuate in a way that will enhance canonicity.[4]

It is impossible to judge whether non-canonical word order in the speech of such young children is non-canonical due to lack of knowledge about word order, or, what is less plausible, due to pragmatic considerations (such as topicalization, focalization and presentation – see section 'A short description of Israeli Hebrew'), which lead to a different word order from the canonical one. Since word order in this study is only gauged for the very earliest clauses produced in any structure, it is assumed that non-canonical word order at such an early stage is the result of a lack of advanced knowledge.

As mentioned earlier, presentational constructions in Hebrew tend to follow a VS word order, and to include a particular set of verbs. These verbs often appear in the children's productions in VS order. Examples from Naomi's corpus are: (at age 2;1.10) *yored geshem*, descend-SG-MS-PR rain 'It's raining', or (at age 2;4.16) *nishbar hagalgal*, break(intr.)-3SG-MS-PS the-wheel 'The wheel broke'. Therefore utterances constructed around such verbs were excluded from analyses of errors (but not from the analyses of curvature), so as not to overestimate the number of errors. Utterances constructed around the following verbs were thus excluded from error

[4] Shuli's corpus is characterized by a peculiar transcription style. In this transcription consecutive utterances are often strung together, unseparated by punctuation marks. It is often impossible to ascertain where one utterance ends and the next begins. Dividing these long strings into separate utterances can lead to very many or very few utterances being coded as non-canonical, depending on how the division is done. In order not to inflate the number of errors in this corpus, repetition of an argument in two (or more) different locations in one utterance was not coded as an error in this corpus only.

analyses: *nigmar* 'to finish (intr.)', *nishbar* 'to break (intr.)', *nishpax* 'to spill (intr.)', *hitparek* 'to fall apart', *nafal* 'to fall', *kaav* 'to hurt (intr.)', *nikra* 'to tear (intr.)', *kara* 'to happen', *yarad* 'to descend' (when used for rain, snow, etc.), *kilkel* (meaning *hitkalkel*) 'to break down' (an erroneous use by one child of a transitive verb pattern instead of an intransitive one). Note, that this cautious measure may lead to underestimating the errors in the corpora.

In defining the argument structure of a given verb I was aided by several dictionaries and articles which deal with the valency of Hebrew verbs or with valency in general (e.g. Stern, 1994; Berman, 1982). For the coding scheme and full list of sources for valency judgements see Keren-Portnoy (2002).

### *The structures found in the corpora*

Altogether there was a potential for 90 structures to be found in all six corpora (that is, 15 different structures in six corpora), but only 64 structures were actually found (see Tables 3a–f for details).

## RESULTS

### *Hypothesis 1: facilitation (acceleration)*

The acceleration hypothesis was tested by checking the shape of each learning curve: a graph plotting the cumulative frequency of verbs learned in the structure, by the age at production of each verb's first canonical clause (see Figures 3 and 4 for examples of such graphs for two structures: SV and VO). For this test, all available data for each of the children was used. The hypothesis was that this curve would be convex, but the acceleration can clearly not continue indefinitely: at some point the learning graphs will reach an asymptote, because the learners have mastered most of the items in a pattern, or because they have stopped focusing on it, and moved on to focus on other structures; this point need not be reached during the periods of observation reported here for all graphs. Therefore, the part of the graph which should be convex according to the acceleration hypothesis is that which depicts the early stage of learning in any structure. Specifically, the graph should start out as convex and may, after a period, become straight or even concave, in which case it would resemble a logistic curve (see footnote 5).

The convexity of the graphs was determined by two tests, one qualitative, by the author's subjective judgement, the other quantitative, by regression analysis. Only graphs with at least four points, i.e. four different dates of new verbs joining the structure, were judged. If a graph starts out as concave, then becomes convex, or *vice versa*, the qualitative judgement was based on the shape of the graph in the part corresponding to the earlier stages, which

TABLE 3. *The structures acquired by each child, order and age of acquisition*

3a: Bareket

| Order of acquiring structures | The structures | Age at acquisition of structure |
|---|---|---|
| 1 | SV | 1;4.9 |
| 2 | VA | 1;5.23 |
| 3 | VO | 1;6.19 |
| 4 | SVO | 1;8.0 |
| 4 | SVA | 1;8.0 |
| 6 | VI | 1;9.12 |
| 7 | SVI | 1;9.28 |
| 7 | VOI | 1;9.28 |

3b: Lior

| Order of acquiring structures | The structures | Age at acquisition of structure |
|---|---|---|
| 1 | VO | 1;11.1 |
| 2 | SV | 2;0.12 |
| 3 | SVO | 2;1.3 |
| 4 | VI | 2;2.0 |
| 5 | VA | 2;2.3 |
| 5 | VOI | 2;2.3 |
| 7 | SVI | 2;2.7 |
| 8 | VIA | 2;2.14 |

3c: Naomi

| Order of acquiring structures | The structures | Age at acquisition of structure |
|---|---|---|
| 1 | SV | 1;7.2 |
| 2 | VO | 1;7.10 |
| 3 | SVO | 1;9.17 |
| 4 | VA | 1;9.23 |
| 5 | VOA | 1;11.1 |
| 6 | VI | 2;0.4 |
| 7 | SVA | 2;0.17 |
| 7 | SVOI | 2;0.17 |
| 9 | VOI | 2;0.18 |
| 10 | SVI | 2;0.24 |
| 11 | SVOA | 2;1.1 |
| 12 | SVIA | 2;3.12 |
| 13 | VIA | 2;4.10 |
| 13 | VOIA | 2;4.10 |
| 13 | SVOIA | 2;4.10 |

TABLE 3. (*Cont.*)

3d: Ofer

| Order of acquiring structures | The structures | Age at acquisition of structure |
|---|---|---|
| 1 | SV | 1;6.25 |
| 2 | VA | 1;10.28 |
| 3 | VO | 1;11.24 |
| 3 | VI | 1;11.24 |
| 3 | VOI | 1;11.24 |
| 6 | SVI | 2;0.6 |
| 7 | SVO | 2;1.2 |
| 7 | SVA | 2;1.2 |
| 9 | SVOI | 2;1.18 |
| 10 | VOA | 2;1.28 |
| 11 | SVOA | 2;3.25 |
| 12 | VOIA | 2;4.7 |

3e: Shuli

| Order of acquiring structures | The structures | Age at acquisition of structure |
|---|---|---|
| 1 | SV | 1;7.2 |
| 2 | VO | 1;7.27 |
| 3 | SVO | 1;8.26 |
| 4 | VOI | 1;9.22 |
| 5 | VI | 1;10.24 |
| 6 | VA | 1;10.29 |
| 7 | SVI | 1;11.16 |
| 8 | SVA | 1;11.20 |
| 9 | VOA | 2;0.4 |
| 10 | SVOA | 2;0.9 |
| 11 | SVOI | 2;0.24 |
| 12 | VIA | 2;1.14 |
| 13 | SVIA | 2;2.3 |
| 14 | SVOIA | 2;3.11 |

3f: Tal

| Order of acquiring structures | The structures | Age at acquisition of structure |
|---|---|---|
| 1 | VO | 1;9·10 |
| 1 | VA | 1;9·10 |
| 3 | SV | 1;9·23 |
| 4 | VI | 1;10·28 |
| 5 | VOI | 1;11·19 |
| 6 | SVO | 2;1·22 |
| 7 | VIA | 2;3·10 |

are the stages of interest here. All available data points for each graph were used in the regression analysis – see below.

The simplest convex curve, a parabola, was fitted to the data points of each graph in the regression analysis. That is, a second degree regression[5] was run, using time – see below – and time squared as the independent variables, and cumulative frequency as the dependent variable. The regression equation is: $Y = b_0 + b_1T + b_2T^2 + \varepsilon$ where $Y$ is the cumulative number of verbs learned in the structure, $T$ the time in weeks which has elapsed from the date in which the first verb was acquired by the child in that structure and $\varepsilon$ is the error term. The constant $b_0$ and the linear coefficient $b_1$ are irrelevant to the judgement of curvature. The quadratic coefficient $b_2$ describes the CURVATURE OF ACCELERATION, and is the one of interest. If it is zero, the regression line is a straight line. If it is positive, the line is convex (accelerating), so that as time progresses more and more verbs are being learned each week. If it is negative, the line is concave (decelerating). The absolute value of $b_2$ depends on the units of time used. For the units used here, weeks, even if $b_2$ is only 0·01, after a year, i.e., for $T = 50$, $T^2 = 2500$, and the quadratic term adds 25 new verbs.

The regression was run after the subjective judgement was completed, and on the complete data for each structure, so that unlike the qualitative judgements, it was not restricted to the first part of the graph. This was done in order to avoid biasing the regression results by qualitatively judging which part of the graph is to be described by the equation. It ensured that the two methods of judgement were independent of each other: one involved subjective human judgement, and the other was completely mechanical. These $b_2$ coefficients were compared with the qualitative judgements, and served as a reliability check on the qualitative judgements. The results are reported in Tables 4 and 5. Table 4 presents side-by-side the subjective curvature judgements and the regression coefficients, and Table 5 summarizes the agreement and divergence between the alternative methods of convexity judgements. Figure 1 presents these statistics graphically.

### *The judgements of the two curvature measures compared*

Altogether 39 graphs were judged for convexity (Table 5 and Figure 1 show the degree of compatibility between the two methods of judgement). Of these, 34 (87%) were judged alike by both methods. Five (13%) were qualitatively judged as convex but fitted with a non-convex regression line, or *vice versa*.

[5] A third degree polynomial could also have been tried, and the full learning curve, a logistic curve, would indeed have produced a third degree curve. However, in most cases the children have not reached the non-convex stage during the data collection period, and a third order regression would have used another degree of freedom and would not necessarily have given a clearer description of the graphs.

TABLE 4. *Curvature judgements for each curve*

| Child's name | Structure | Age at acquisition | order of acquisition | Qualitative judgement of curvature | quadratic coefficient of regression | significance of quadratic coefficient: *p* value | Percentage of variance explained: R2 |
|---|---|---|---|---|---|---|---|
| Bareket | SV | 1;4.9 | 1 | 1 | 0·0286** | $p < 0·01$ | 0·98 |
| | VO | 1;6.19 | 3 | 1 | 0·0279 | 0·32 | 0·78 |
| | VI | 1;9.12 | 6 | · | · | · | |
| | VA | 1;5.23 | 2 | 1 | 0·0228** | $p < 0·01$ | 0·98 |
| | SVO | 1;8.0 | 4 | · | · | · | |
| | SVI | 1;9.28 | 7 | · | · | · | |
| | SVA | 1;8.0 | 4 | · | · | · | |
| | VOI | 1;9.28 | 7 | · | · | · | |
| Lior | SV | 2;0.12 | 2 | 1 | 0·0491 | 0·06 | 0·97 |
| | VO | 1;11.1 | 1 | 1 | 0·0569** | $p < 0·01$ | 0·96 |
| | VI | 2;2.0 | 4 | · | · | · | |
| | VA | 2;2.3 | 5 | · | · | · | |
| | SVO | 2;1.3 | 3 | 0 | 0·0033 | 0·96 | 0·93 |
| | SVI | 2;2.7 | 7 | · | · | · | |
| | VOI | 2;2.3 | 5 | · | · | · | |
| | VIA | 2;2.14 | 8 | · | · | · | |
| Naomi | SV | 1;7.2 | 1 | 1 | 0·0283** | $p < 0·01$ | 0·98 |
| | VO | 1;7.10 | 2 | 1 | 0·0108** | $p < 0·01$ | 0·98 |
| | VI | 2;0.4 | 6 | 1 | 0·0164* | 0·03 | 0·96 |
| | VA | 1;9.23 | 4 | 0 | −0·0016 | 0·53 | 0·97 |
| | SVO | 1;9.17 | 3 | 1 | 0·0262** | $p < 0·01$ | 0·99 |
| | SVI | 2;0.24 | 10 | 1 | 0·0204** | $p < 0·01$ | 0·98 |
| | SVA | 2;0.17 | 7 | 1 | −0·0027 | 0·30 | 0·98 |
| | VOI | 2;0.18 | 9 | 1 | 0·0253* | 0·01 | 0·91 |
| | VOA | 1;11.1 | 5 | 0 | −0·0006 | 0·73 | 0·97 |
| | VIA | 2;4.10 | 13 | · | · | · | |
| | SVOI | 2;0.17 | 7 | 1 | 0·0298** | $p < 0·01$ | 0·98 |
| | SVIA | 2;3.12 | 12 | · | · | · | |
| | SVOA | 2;1.1 | 11 | 1 | 0·0613 | 0·05 | 1·00 |
| | VOIA | 2;4.10 | 13 | · | · | · | |
| | SVOIA | 2;4.10 | 13 | · | · | · | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ofer | SV | 1;6.25 | 1 | 1 | 0·0402** | $p<0·01$ | 0·98 |
| | VO | 1;11.24 | 3 | 0 | −0·0323** | $p<0·01$ | 0·99 |
| | VI | 1;11.24 | 3 | 1 | 0·0097 | 0·15 | 0·96 |
| | VA | 1;10.28 | 2 | 0 | −0·0239** | $p<0·01$ | 0·97 |
| | SVO | 2;1.2 | 7 | 1 | 0·0245 | 0·10 | 0·97 |
| | SVI | 2;0.6 | 6 | 0 | 0·0118* | 0·02 | 0·98 |
| | SVA | 2;1.2 | 7 | 0 | −0·0263** | $p<0·01$ | 0·99 |
| | VOI | 1;11.24 | 3 | 1 | −0·0014 | 0·84 | 0·92 |
| | VOA | 2;1.28 | 10 | · | · | · | |
| | SVOI | 2;1.18 | 9 | 1 | 0·0090 | 0·10 | 0·96 |
| | SVOA | 2;3.25 | 11 | 0 | −0·0908 | 0·05 | 1·00 |
| | VOIA | 2;4.7 | 12 | · | · | · | |
| Shuli | SV | 1;7·2 | 1 | 1 | 0·0310** | $p<0·01$ | 0·97 |
| | VO | 1;7.27 | 2 | 1 | 0·0208** | $p<0·01$ | 0·97 |
| | VI | 1;10.24 | 5 | 1 | 0·0232** | $p<0·01$ | 0·98 |
| | VA | 1;10.29 | 6 | 1 | 0·0129 | 0·16 | 0·97 |
| | SVO | 1;8.26 | 3 | 1 | 0·0329** | $p<0·01$ | 0·98 |
| | SVI | 1;11.16 | 7 | 1 | 0·0188 | 0·51 | 0·84 |
| | SVA | 1;11.20 | 8 | 1 | 0·0060 | 0·22 | 0·99 |
| | VOI | 1;9.22 | 4 | 1 | 0·0143** | $p<0·01$ | 0·97 |
| | VOA | 2;0.4 | 9 | · | · | · | |
| | VIA | 2;1.14 | 12 | · | · | · | |
| | SVOI | 2;0.24 | 11 | 1 | −0·0839* | 0·01 | 0·92 |
| | SVIA | 2;2.3 | 13 | · | · | · | |
| | SVOA | 2;0.9 | 10 | · | · | · | |
| | SVOIA | 2;3.11 | 14 | · | · | · | |
| Tal | SV | 1;9.23 | 3 | 1 | 0·0084* | 0·01 | 0·98 |
| | VO | 1;9.10 | 1 | 1 | 0·0162** | $p<0·01$ | 1·00 |
| | VI | 1;10.28 | 4 | · | · | · | |
| | VA | 1;9.10 | 1 | 1 | 0·0108 | 0·08 | 0·98 |
| | SVO | 2;1.22 | 6 | · | · | · | |
| | VOI | 1;11.19 | 5 | · | · | · | |
| | VIA | 2;3.10 | 7 | · | · | · | |
| Total | 64 | | | 39 | 39 | | |

Legend: highlighted rows – structures for which the qualitative and quantitative curvature judgements do not match. A dot signifies insufficient data. *, significance level of 5%; **, significance level of 1%.

TABLE 5. *Agreement between curvature judgement methods*

| Qualitative Judgement | Accelerating graphs | | Non-accelerating graphs | | Judgements agreeing |
|---|---|---|---|---|---|
| Regression coefficient | Number | Percentage (out of total accelerating) | Number | Percentage (out of total non-accelerating) | Number |
| Positive | 28 | 90% | 2 | 25% | 28 |
| of which significant | 18 | 58% | 1 | 13% | |
| Negative | 3 | 10% | 6 | 75% | 6 |
| of which significant | 1 | 3% | 3 | 38% | |
| Total | 31 | 100% | 8 | 100% | 34 (87%) |

Highlighted cells: matching judgements by the two methods.

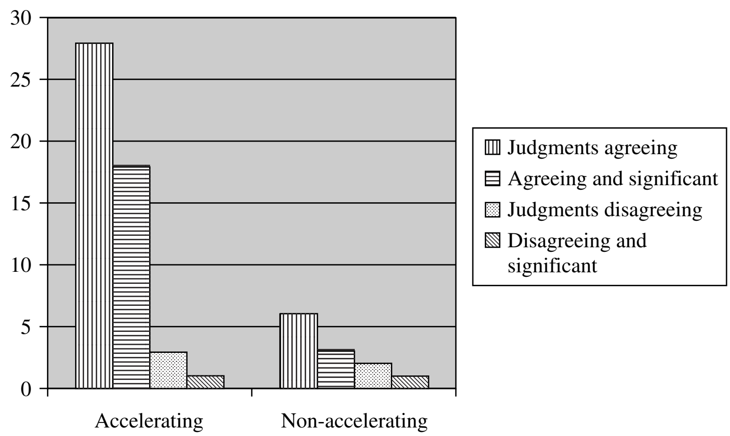


Fig. 1. Compatibility of judgements of curvature.

However, of these, only two (5%) second order ($b_2$) coefficients were significant, and therefore can be seen as clearly contradicting the qualitative judgements. Of these, one graph was qualitatively judged as convex but was fitted with a significantly concave regression line, and the other was qualitatively judged as non-convex but was fitted with a significantly convex regression line (see Figure 2).

There are different reasons for the conflicting judgements in the two cases: in the case of SVOI in Shuli's corpus (Figure 2a), the graph accelerates at first, but then levels off, which results in a negative regression coefficient, i.e. a curve judged non-convex. However, as I am only interested in the early stages of learning each structure, this conflicting judgement does not present a problem. As mentioned above, the regressions were run on the full

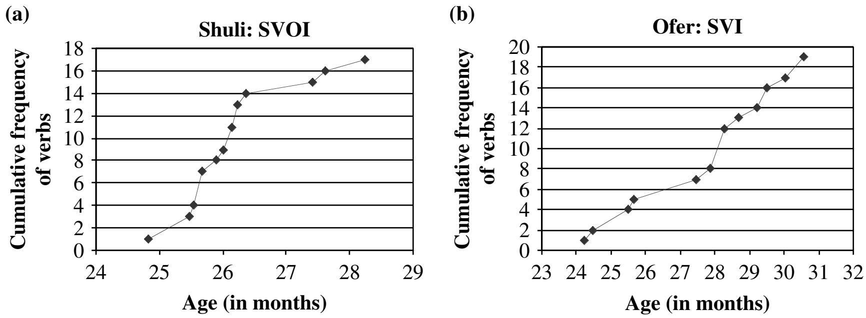


Fig. 2. The two graphs which received conflicting judgements (a) and (b).

data for each structure, without imposing cut-off points which would be based on qualitative evaluation. This, however, results in the regression failing to give more weight to the early stages in the acquisition of a structure than to later stages. The second case of conflicting judgements is that of SVI in Ofer's corpus (Figure 2b). Here the regression line fitted to the graph is convex. However, since the convexity is only the result of two points deviating from the straight line, I did not think that this graph merited the description 'convex' in any real sense.

To summarize the compatibility between the two methods of judgement: out of the 31 curves qualitatively judged as convex, 28 (90%) were fitted with a positive coefficient, and 18 of the 28 proved statistically significant. Out of the eight curves qualitatively judged as non-convex, six (75%) were fitted with a negative coefficient, two of which are statistically significant.

### *Facilitation – results*

Figures 3 and 4 portray the learning graphs of a sample of the structures, and Table 4 lists the curvature judgements for all structures. Of these 39 structures 31 (79%) were found to be convex by the qualitative judgement (see Table 6), as expected (Henceforth, all references to convexity are based on the qualitative judgements. 30 structures were judged as convex by the quantitative method). The eight (21%) non-convex curves were found in three of the corpora, and five of them come from the same corpus (out of a total of ten graphs which could be judged for convexity in this corpus). Excluding this corpus, which is unique in its tendency for non-convex learning graphs, 90% of the curves in the remaining corpora are convex.

### *Hypothesis 2: errors and practice*

For the first 20 clauses in each structure two measures were computed: the number of different verbs which generated these first clauses and the

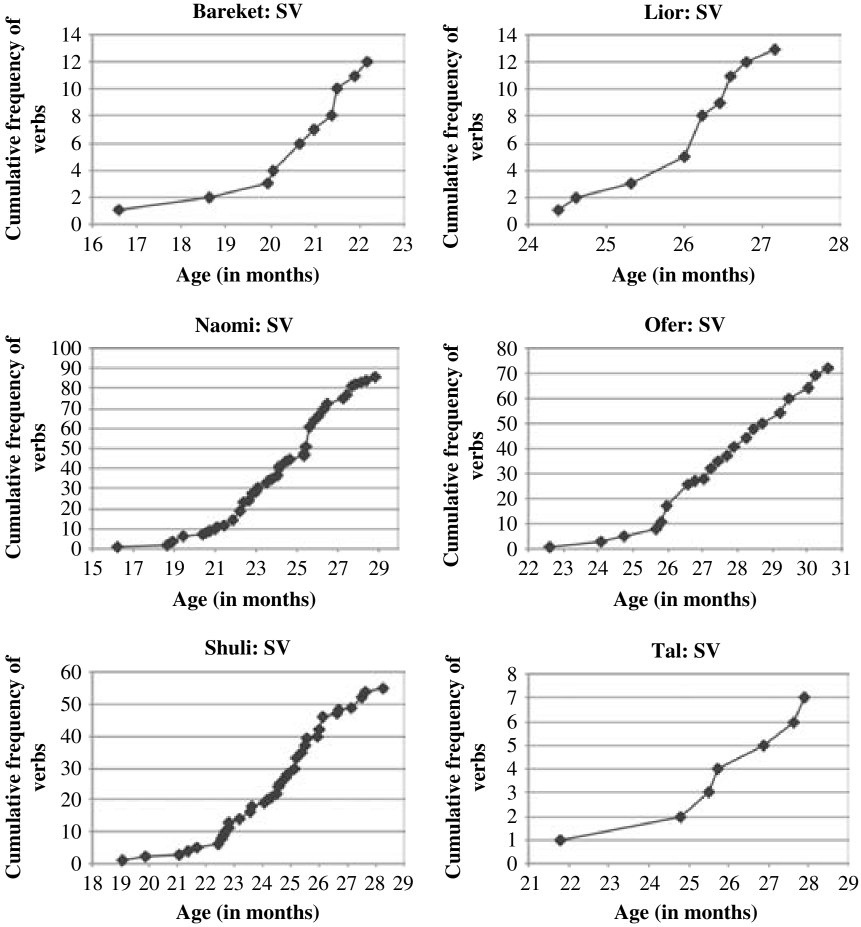


Fig. 3. SV.

number of non-canonical clauses among them. These were then converted into proportions out of 20. In the case of structures with fewer than 20 but more than three clauses proportions were computed in the same manner over the total number of utterances in each structure. Structures for which curvature judgements could not be made (because the learning graph included fewer than four points), but in which at least four clauses had been produced were included in this analysis.

For this test only data collected during the weekly half-hour session were used. Parental reports and utterances collected outside the recording sessions by the researchers were excluded from the analysis, in order to keep the

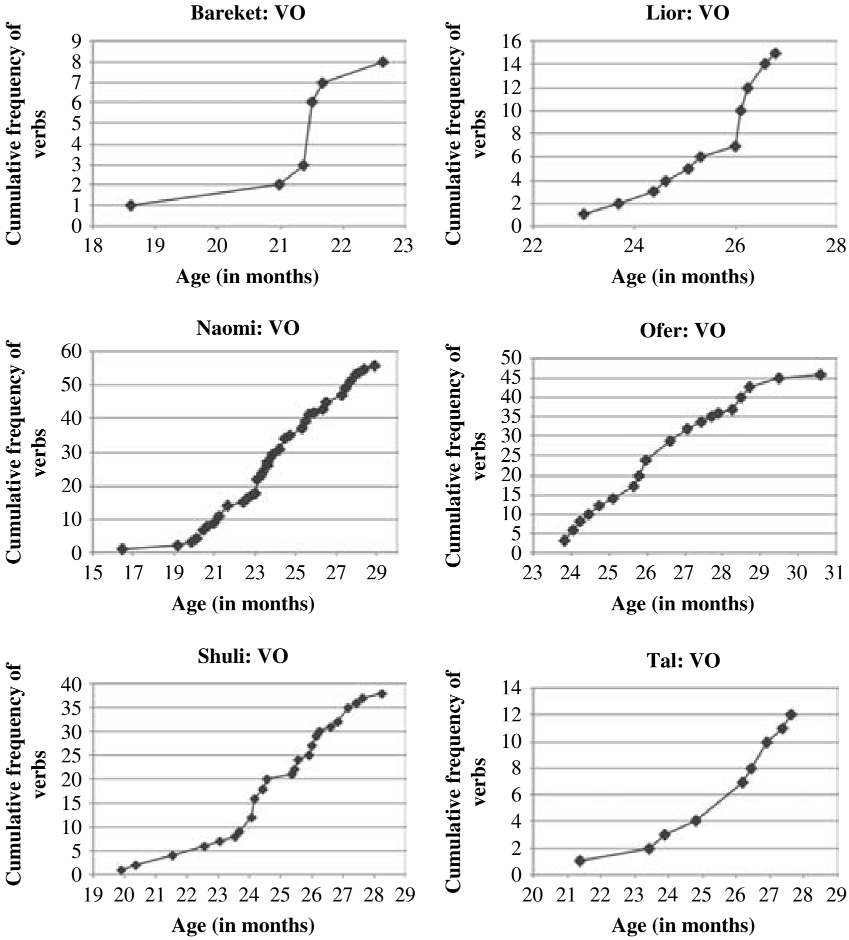


Fig. 4. VO.

sampling rate of one half hour per week as regular as possible, so that the period during which the first 20 clauses were produced would indeed correctly reflect the rate of acquisition of each structure.

A correlation was run between the proportion of verbs and the proportion of errors within the first 20 clauses, utilizing standardized scores which were computed for each corpus individually. This scale highlights differences inside each corpus between the structures acquired in that corpus, while correcting for the differences between children in their propensity to make errors or to have many or few verbs generating their earliest clauses.

TABLE 6. *Occurrence of accelerating graphs in the corpora*

| | Number | Percentage |
|---|---|---|
| Accelerating graphs | 31 | 79% |
| Non-accelerating graphs | 8 | 21% |
| Total | 39 | 100% |

TABLE 7. *Number of verbs among accelerating and non-accelerating structures*

| | *N* | Mean number of verbs | Std. Deviation of number of verbs |
|---|---|---|---|
| Accelerating structures | 31 | 0·10 | 0·86 |
| Non accelerating structures | 8 | 0·38 | 0·80 |

Note: Recall that the scores were standardized inside each corpus.

Because two children had no recorded errors in this sample, their error scores could not be standardized, and they were excluded from the analysis.[6]

The results of the correlation run on the standardized proportion scores, across all structures and four of the corpora are: $n=37$, $r=(-0{\cdot}38)$, $p<0{\cdot}05$, one-tailed ($p=0{\cdot}010$). The correlation is negative, as expected, moderate in size, and significant.

The result supports the construct of practice suggested here: structures which are practiced less intensively show different characteristics from structures which undergo more intensive practice, where a tendency to make many errors and to use few verbs to construct clauses in a structure is evidence for intensive practice.

*Hypothesis 3: number of verbs and acceleration*

As in the previous test, only data from the half-hourly recordings were used.

Accelerating structures were compared to non-accelerating ones, as to the mean proportion of different verbs which generate the first 20 clauses in each structure (these proportions were computed as explained for hypothesis 2). Standardized Z-scores were used (as for hypothesis 2).

Results (see Table 7): $n=39$, $n$(accelerating) $=31$, $n$(non-accelerating) $=8$. The difference between the means is 0·28, $t=0{\cdot}833$, $p>0{\cdot}05$ (one tailed, df $=37$). The difference is in the hypothesized direction: more verbs generate the earliest clauses in the non-accelerating than in the accelerating structures,

[6] These data might be taken to imply that for these children learning may be error-free. However, errors are very rare and are therefore hard to sample, and such corpora may be suspect of having been sampled with too coarse a sieve.

TABLE 8. *Number of errors among accelerating and non-accelerating structures*

| | $N$ | Mean number of errors | Std. Deviation of number of errors |
|---|---|---|---|
| Accelerating structures | 26 | 0·07 | 1·03 |
| Non accelerating structures | 7 | −0·45 | 0·44 |

Note: Recall that the scores were standardized inside each corpus.

hinting that non-accelerating structures undergo less practice than accelerating ones. However, this difference is small and not significant.

### *Hypothesis 4: errors and acceleration*

As in the previous test, only data from the half hourly recordings were used.

The mean proportion of errors among the first 20 clauses in non-accelerating structures was compared to that in the accelerating structures (these proportions were computed as explained for hypothesis 2). As explained above, standardized scores could not be computed for two corpora in which no errors were recorded, and this comparison therefore utilized only 33 structures produced by four children.

Results (see Table 8): $n=33$, $n$(accelerating)$=26$, $n$(non-accelerating)$=7$, the difference between the means is $-0{\cdot}52$ and it is in the expected direction: there are fewer errors in the non-accelerating structures. Given that the two groups differ so much in size, equality of variance is not assumed (Levene's test for equality of variances: $F=4{\cdot}081$, $p=0{\cdot}052$). The results are significant: $p<0{\cdot}05$ (one tailed, df$=24{\cdot}023$).

The mean number of errors in the non-accelerating structures was, as expected, significantly lower. This accords with the claim that non-accelerating structures are structures where learning is achieved without practice, and therefore errors, which are a sign of practice, are rare in these structures. Note that the number of different verbs generating the earliest clauses in the non-accelerating structures also showed a tendency to be greater than that in accelerating structures (Hypothesis 3), strengthening the claim of less practice in these structures. However, that result was not significant.

## DISCUSSION

I have shown in this paper that syntax learning is item based, but that the different items do not form isolated and insulated bits of stored information. Rather, early learning promotes subsequent learning, making it progressively easier to learn new items of the same kind as those already acquired. It has also been shown that practice plays a role in this process, involving trial and error and recurrent use of the same items. It was found that in some cases learning can proceed with little or no practice, resulting in an even rate of acquisition of items for such patterns. I shall now elaborate on some aspects of the model.

As regards facilitation, like Tomasello and Lieven and their colleagues, I claim that syntactic knowledge is item-specific: it refers to words, not to any abstract concepts or categories, nor to abstract linguistic structures. The uniqueness of the model lies in the suggested course by which item-based knowledge grows and is propagated. First, it is claimed that verbs, like other items of knowledge, are not isolated from other stored items. Why assume otherwise, in a brain that is known to be constantly comparing and noting similarities? On the contrary: I show that previous knowledge aids in gaining new knowledge, which in turn shows that new items are somehow associated with old ones. Right from the start new items which are learned and stored in memory begin to form a system, a network of connections, which is very sparse and weak at first, and gradually grows denser, with some connections growing in strength, others weakening or disappearing. Savage, Lieven, Theakson & Tomasello (2003) express a view which is akin to this in spirit, in that instead of stressing a prolonged item-based beginning where no abstraction exists, they describe the move from isolated items to a system, or in their terms – to ABSTRACT REPRESENTATIONS – as a continuous process, occurring over the preschool years. Once syntactic knowledge is conceptualized as a system of interconnected items, the place of constructions in the proposed model can be reformulated.

The role of structures in the model offered here is quite different from their role in models where constructions are taken to be linguistic entities (e.g. Tomasello, 2000) which are stored in memory, and even have semantic content attached to them (Goldberg, 1999; Goldberg, Casenhiser & Sethuraman, 2004). I see the structures that a verb participates in (i.e. SV, VO and their likes) as one of the most important characteristics of each specific verb in the endstate system. While the system is still being constructed, however, argument structure, alongside semantics, is a critical dimension on which verbs can be compared to one another. Such comparisons lead to verbs being used in the same structures as other verbs of similar argument structure. The result is that at least one path whereby facilitation and development take place is that outlined by each structure: learning proceeds by new verbs being used in the same way as old ones, that is – in the same structures.

This is quite distinct from models where the constructions are real linguistic entities. To claim that constructions are stored entities, separate from the verbs which are used in them, spells a return to models in which rules exist outside the lexicon and refer to abstract concepts, to entities which are not words. In such a model words must somehow be mapped to these abstract entities. However, it seems redundant to assume such separate linguistic entities. Since each verb must be connected to or associated with one or more constructions, it is posited that this information is stored together with the specific verb. Instead of positing that abstract constructions carry meaning (e.g. Goldberg, Casenhiser & Sethuraman, 2004), it is posited that the possible alternations in which a verb can participate are an integral part of the knowledge pertaining to that verb, and this knowledge can be inferred mainly from the verb's meaning (Levin, 1993).

Similar verbs would tend to cluster together in 'mental space', by forming dense clusters of interconnections among them. Such clusters may be thought of as categories or abstract concepts, so that the item most connected to all others in the cluster is the category's prototype. Constructions, like other abstract concepts, may simply be such clusters, created by interconnections among verbs which participate in similar sentence structures. Abstract concepts of this kind may exhibit graded membership, fuzzy boundaries, etc. This is in line with linguistic models which depict adult linguistic knowledge of constructions as consisting of categories which are centered around prototypes (e.g. Taylor, 1998; Goldberg, 1999). This may also explain phenomena such as SEMANTIC SATURATION (Schlesinger, 1995) or COERCION (Taylor, 1998) whereby peripheral items are assigned traits which characterize the prototype.

Up to this point the gradual and continuous character of the development of syntactic structures was stressed, the fact that early knowledge supports the acquisition of later knowledge right from the start. However, the same course of development described here, the acceleration in the number of new items joining a structure has, in the language development literature, sometimes been taken to signify a qualitative change, some 'insight' or generalization occurring, after some CRITICAL MASS of items has been learned (see e.g. Goldfield & Reznick (1990) in reference to lexical learning; Tomasello (2000) in reference to syntax). The reported results may also be interpreted as showing that following the initial practice period, and having reached the necessary critical mass of verbs learned in a structure, children have an insight into the behavior of verbs, which makes learning additional new verbs easier. The extent of the critical mass that is necessary for analogy to start operating is debatable. A much smaller critical mass may be necessary than that claimed by Lieven, Pine, Tomasello and their collaborators (Tomasello, 1992; Lieven, Pine & Baldwin, 1997; but see a somewhat different view expressed in Savage, Lieven, Theakson & Tomasello, 2003). In fact, Tomasello himself (2000) raises this possibility, by suggesting that for analogies to be possible 'it may be that the critical factor is the number of different verbs heard in the construction'. If so, a very small critical mass need be reached for analogies to start operating in production, since long before a critical mass of verbs has been PRODUCED in any structure, probably more than enough verbs had been HEARD in that structure.

Another new claim that I make is that learning syntax is effected through practice on the early items acquired in any structure. The idea of practice aiding future development has also been suggested in other areas of language development. McCune & Vihman (2001) suggest that the experience gained from varied, frequent, and consistent consonant production in babbling and in early word production paves the way to earlier acquisition of the first referential words. Elbers & Wijnen (1992) and Elbers (2000) have also suggested that language work, which includes practice, aids development, and have shown examples of language work operating in the move from babbling to first words, and in syntax at a later stage than the one described here, the transition around 2;6 to what they term SYNTACTIC SPEECH – the appearance of closed class words. I have suggested two variables which can be taken as evidence for practice: intensive use and errors, and have shown that these two variables can indeed account for the difficulty and gradualness with which learning first occurs in most structures.

The portrayal of syntactic development as a process which involves practice and problem solving stresses the active and productive role of children in the developmental process. This role is often ignored by modern theories, which posit as the major process through which syntax is initially acquired either (a) rote-learning or (b) learning triggered by innate knowledge. Neither the passive soaking-up of unanalysed items nor the automatic 'setting' and maturing of innate knowledge seem the most suitable metaphors. Learning one's first language must involve a gradation of tasks and processes, some of which may be achieved without attention or consciousness, while others, such as aspects of syntax learning, involve much more active problem solving and effort. Both the intensive use of verbs and the error patterns that this study has revealed support this more active view of the learning child.

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